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or their widows. A fund of \$2,500,000 taken from the \$10,000,000 Rockefeller gift of 1910 has been set aside for this purpose. This pension system will grant to men who have attained the rank of assistant professor or higher, and who have reached the age of 65 and have served 15 years or more in the institution, 40 per cent. of their salary and an additional 2 per cent. for each year's service over 15. The plan also provides that at the age of 70 a man shall be retired unless the board of trustees specially continues his services. The widow of any professor entitled to the retiring allowance shall receive one half the amount due him, provided she has been his wife for ten years.

MISS ROSA MORRISON, for nearly forty years superintendent of women students of University College, London, has bequeathed \$20,000 to the college to establish scholarships in English and German.

THE thirty-eighth annual commencement of the Colorado School of Mines will be held on May 24, when fifty-two graduates will receive their degrees. The address of the day will be given by Mr. William Lawrence Saunders, of New York, president of the Ingersoll-Rand Company.

DR. E. I. WERBER, assistant in anatomy at the Johns Hopkins University, has been appointed instructor in anatomy at the University of Wisconsin.

DR. DURANT DRAKE, of the University of Illinois, has been appointed associate professor of philosophy at Wesleyan University.

DR. JAMES A. BABBITT has been promoted to professor of hygiene and physical education at Haverford College.

MR. C. M. GILLESPIE, of Yorkshire College, has been appointed to a newly established professorship of philosophy at Leeds.

DISCUSSION AND CORRESPONDENCE

A DEFENCE OF THE "NEW PHRENOLOGY"

ALTHOUGH I am not a partisan of the traveling phrenologist, I am a believer in cerebral localization or, putting it in more general

form, in the localization of functions in the central nervous system. If we must make a choice between phrenology (supposing for the moment that phrenology is equivalent to localization of function), and the conception that mental processes are something transcending cerebral organization and cellular processes, then I am a phrenologist. It is evidently in this latter sense of localization that Professor Franz¹ uses the term "new phrenology."

It is true that Marie and von Monakow have shown that certain of the more or less current conceptions of focal or insular representation of cerebral function, particularly those concerning the speech center, are no longer tenable, but neither Marie nor von Monakow has denied that certain definite fibers arise from definite circumscribed areas of cells in the cerebral cortex and run to certain definite end stations. Indeed, no point of nervous anatomy or physiology seems better established than this. And stimulation of a definite, circumscribed area of the cerebral motor cortex of any one animal always elicits a response of a definite group of muscles, and never of any other groups. This definite, circumscribed cell area constitutes the focal or insular motor representation in the cerebral motor cortex of this particular group of muscles. Such a circumscribed area, frequently marked off from surrounding cells by a boundary of non-nervous tissue, is commonly known as a motor center.

It would however be an error to suppose that this group of cells is an isolated group. It has, through afferent association neurones, connections with practically every portion of the cerebral hemisphere of the same side; through commissural neurones, with practically every portion of the opposite side, and through afferent projection neurones, it is brought into relation, directly or indirectly, with the cerebellum, spinal cord and other structures. The circumscribed area of cells thus becomes a part of an extremely complex and extensive *motor system*, but in such participation it

¹ SCIENCE, 1912, N. S., XXXV., p. 321.

loses nothing in definiteness of location or of function. The conception of a circumscribed motor center must be superseded by the conception of a motor system or mechanism. It is to such a mechanism that we may apply the conception of integration as developed by Sherrington. Integration is essentially a dynamic rather than a morphological process; but integration implies a certain definiteness of relationships, morphological as well as dynamic, throughout any one process. We have already stated that stimulation of the particular group of cells always evokes a response of a particular group of muscles—contraction of one set and relaxation of their antagonists. And since this phenomenon of group movement is constant from day to day or year to year in any one individual, we are justified in assuming that a certain rather constant morphological mechanism integrates certain rather constant relations in time and space to a fairly constant result. This is the essence of the modern dynamic view of localization of function.

Let us apply this conception to the solution of one of the problems which puzzle Professor Franz. He cites the experiments of dividing two motor nerves and suturing the central end of one to the peripheral end of the other, with the subsequent recovery, after a period of paralysis, of movement in the respective groups of muscles supplied. The regeneration of the nerves undoubtedly means that muscle group *A* is now innervated by fibers arising from cells in the area which previously supplied muscle group *B*. There is no necessity for postulating any further anatomical change, and no basis in fact for such a postulate, even if it were necessary, since no new nerve cells arise after birth in the forms used for the experiment. We must seek an explanation, either in the relationships of the cells and their life processes, or in the entrance of some psychic or mental factor (and hence on Professor Franz's own argument, some unknown factor so far as its localization is concerned) into the readjustment.

Fortunately, the relationships of the cells and their life processes offer us some hope of

a solution. We have already mentioned the fact that the cellular insula is in relation with practically every other portion of the same cerebral hemisphere, and we should emphasize the fact that the response of the motor cells is determined largely by these afferent impulses. In the absence of afferent impulses from the muscles to which they send fibers, the motor cells cause an uncertain and inaccurate response. The mechanism of integration, while not completely wrecked, is damaged and rendered inaccurate. In the process of regeneration of the severed nerves, the sensory (in case it was previously interrupted) as well as the motor connection of the muscle with the cortex has been restored. Impulses coming in over the old sensory route and reaching their usual motor cell destination in the cortex will now produce confusion of motor response. But the ocular path is open and the animal sees its limbs. An animal which has lost all sensation in a limb, through section of the sensory roots, becomes able to control the movements of the apæsthetic limb through its visual mechanism. When the eyes are bandaged, the motor embarrassment of the apæsthetic limb returns. (Bickel.) The ocular path affords one possible, and probable, explanation of the return of motor function in the muscle groups whose nerves were severed. But the possibilities of recovery after transposing and suturing the nerves are by no means exhausted. The afferent impulses from the muscles do not reach their motor cell destinations over one neurone, but over a series of neurones. Between the cortical termination of the afferent path and the motor cells, there are intercalated association neurones. In the early period of recovery the confusion caused by the access of afferent impulses to the wrong motor end station produces an unusual stress in that particular region, and impulses may flow over previously unused channels, thereby eventually reaching, more or less indirectly, the proper destination. The final condition of equilibrium in the system will be reached when the association path from afferent cortical ending to the proper motor cell comes to be the one most

easily followed. The experiment of transposing and suturing motor nerves is successful only when nerves whose central terminations are relatively close to each other are used for the purpose. I am inclined to regard the sensory readjustment as essentially a dynamic rather than as an anatomical change.

This is only a simple case, and the physiologist does not get very far in his experiments without encountering more serious difficulties. In the higher vertebrates the situation is further complicated by the presence of two motor systems—the phylogenetically old and the phylogenetically new, *e. g.*, the pyramidal tract, as von Monakow² has pointed out on morphological grounds and as I have indicated (1909) from experimental considerations. In case of injury to any part of the newer system, the phylogenetically older system may assume, in a certain degree, the functions previously belonging to the newer system. The theory of localization of function in its relation to the phylogenetic development of the nervous system enables us to give a rational and intelligible account of many nerve processes, though the lack of experimental data leaves others unilluminated. It is but fair to state in this connection that the only physiologist of modern times who maintained a perfectly consistent attitude on cerebral localization was Goltz, who denied it in toto.

It follows, as a consequence of the postulate of integration, that the character of the activity of any particular mechanism is determined, not by any one constituent part, but that the final action is the sum of the activities of the various constituent parts. A change in the relation of the afferent impulses produces a change in the motor reaction. Indeed, we may probably say that if all the relations are the same in two successive processes, even though they may be separated in point of time, the motor reactions must necessarily be alike. This is certainly true of some reactions, and may be regarded as a restatement of Hermann's law of specific re-

sponse to stimulation, and is in line with C. O. Whitman's wider generalization that "organization shapes behavior."

The theory of integrative action may be extended to the field of the special senses. The psychologists, or certain of them, have argued that, since neither the afferent nerves of special sense nor the central cells about which they terminate are sufficiently different anatomically from other afferent nerves or central cells to explain the specific energy of the sensory nerves, this difference in sensation must depend upon consciousness. In this they have been but miserable comforters. Since no one has yet told us what consciousness is, attributing a certain function to consciousness is tantamount to saying that we know little about it. If the ultimate sensation of which we become aware is due not to a single afferent nerve and a circumscribed end station alone, but to the peculiar relationships of these structures to other parts of the nervous system as well, the aspect of the problem changes somewhat. The visual sensations, for example, may be the resultant of afferent impulses over the optic nerve acting on various central stations, some of which, as shown by the course of the association tracts, may be remote from the occipital area of the cerebral cortex. If a particular sensation is the result of the action of a definitely localized integrating mechanism, consciousness, in so far as it deals with this particular sensation, is also a result of the activity of a definite organization, morphological and functional, of the brain, and is related to a fairly definite region or regions. It is doubtful whether the psychologists are in possession of sufficient facts to show that such a hypothesis of integration is impossible or even improbable. Few physiologists will deny that our analysis of the motor system and, *a fortiori*, of the system of the special senses, is incomplete, and that we do not yet know all we need to know about them. Few will deny that the analysis is difficult, and that we may be a long time finding out. I am free to admit the possibility that the views stated here may not be the final views in the matter. I am ex-

²"Aufbau und Lokalisation der Bewegungen beim Menschen," Leipzig, 1910; "Über Lokalisation der Hirnfunktionen," Wiesbaden, 1910.

tremely loath to admit that the analysis of the motor and sensory systems is impossible, or that it will finally be necessary to postulate any agency which transcends matter and energy as we ordinarily know them, to complete that analysis. I would strongly insist that even our present methods of analysis have not as yet been shown incapable of yielding further information. I am not quite sure, from reading Professor Franz's paper, of his position in regard to localization of the motor system, or of certain sensory systems, but I have given this survey of them in order better to show by comparison, that similar methods may be applied to the analysis of mental processes.

For my part I find it impossible to gain a clear idea of how the brain functions as a whole in motor processes. I do believe, however, that we may gain a certain degree of clearness of ideas if we suppose that certain definite circumscribed cell areas, and no others, acting through their association tracts, may evoke a definite motor reaction, and no other motor reaction. Similarly, I find it extremely difficult to see how the brain, acting as a whole and without reference to circumscribed cerebral areas or to integration systems involving two or more such areas, may give rise to a mental process. I can picture to myself a conceivable way in which several cell groups or systems, acting together in a particular manner and without special reference to the rest of the brain, may give rise to a particular mental process or conception made up of certain definite mental elements which are related in a definite way. Other parts of the brain may subsequently be involved in succeeding mental processes, but a definite order of succession may well be followed. This is, as I take it, the only fundamental difference between Professor Franz and the advocates of cerebral localization. It appears to me that the localizationists, or phrenologists if you please, have somewhat the better of the argument, inasmuch as one very valuable method of getting at the working of a mechanism as a whole is by taking it to pieces and studying the properties and reactions of each

piece separately, and attempting to determine the relations of the pieces to one another. The validity of each view must, however, be determined by the results which it can produce when applied to the analysis of nervous functions.

To many of us, mental states mean the resultant of the various sensory impressions of the moment, modified, it may be, by stored-up impressions of past incidents—the memory of past sensory impressions. To many of us, it appears, also, that sensory impressions are closely connected, in a dynamical way, with certain definitely localized anatomical mechanisms in the central nervous system. If it be true that there exist in the central nervous system such integrative sensory mechanisms, and if it also be true that mental states are but the integration, in a definite sequence in space and time of these sensory impressions, it follows that there must also be localization of mental processes with reference to these integrative mechanisms. It may be that our views of definitely localized integrative mechanisms and their functions are unfounded, but they appear to be the simplest views which, in the light of our present knowledge, we are justified in retaining.

This is not to insist that any one shall become a new phrenologist against his will, but is meant simply as a justification for those to whom it still appears that localization of function, in the sense of its dependence upon the action of localized integrative mechanisms, "is a wholesome doctrine and very full of comfort."

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MR. DOOLEY ON SCIENCE: BEING A PROTEST AGAINST
THE VIOLENCE OF THE GENETICIST

"SCIENCE is a great thing, Hinnissy," said Mr. Dooley. "Av coorse t' a man av yer onidjicashun th' rale progriss iv science manes but little, but to thousands iv collidge proffessors 'tis the brith av life. Av coorse 't isn't much iv a livin' the pore divils git, but th' likes iv them don't nade t' spind money like you and me—they havin' no bad habits."